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Biofuels: Impact on Food Productivity, Land Use, Environment and Agriculture

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Abstract

India's growing population and economy is creating an increased demand for energy, food, livestock products, timber, paper, etc., with implications for land use. Since the larger rural population depends on land for earning their livelihood. On the verge of losing global fossil fuel resources, the Indian government and energy industry are considering the augmentation of bio-fuel production. India has announced a national biofuel policy and launched a large program to promote biofuel production, particularly on wastelands: its implications need to be studied intensively. Studies have shown that area under agriculture and forest has nearly stabilized over the past 2–3 decades. Energy security and climate change are the two major driving forces for worldwide bio-fuel development which also have the potential to stimulate the agro-industry. Nonetheless, there are other problems associated with biofuel usage such as automotive engine compatibility in long term operation and also food security issues that stem from biofuel production from food-grade oil-seeds. This paper examines India's fourfold approach towards: biofuel development, energy efficiency, land use, food productivity and sustainable environment including impact on agricultural market. The current study indicates a promising and bright future for bio-fuels in terms of being a substitute for conventional energy sources like coal and petroleum. Also a rise in value added services from the agricultural sector leading to a gain benefitting the owners of land and labours has been observed. Hence, the emergence of biofuels can (in this way at least) be a positive force for the economy as a whole.

Keywords: Bio-fuels, wasteland, energy security, food productivity, agriculture.

1. Introduction

India's emerging economy has a growing demand for energy. In 2040, India is expected to account for 15% of the world's oil demand [1]. Facing the decline of global fossil fuel resources and the risk of climate change, the Indian government and energy industry are considering the long-term expansion of biofuel production in order to increase energy security [2]. Biodiesel and bioethanol will play a prominent role to meet the growing fuel demands of the transport sector [3]. While biodiesel has a wide range of applications for trucks, busses, agricultural machinery or for water pumps [4,5],ethanol is mainly used to substitute petrol for individual transport, which is projected to have enormous growth rates over the coming 30 years [3]. The interest in biofuels in the industrialized countries, apart from promoting energy security, is also aimed at mitigating the threat of climate change by substituting petroleum fuels. According to IPCC (2007) biofuels have a large potential towards GHG emissions reduction in the transportation sector. On the other hand, developing countries such as India have multiple goals in promoting biofuels, such as promoting energy security, rural development and reclamation of degraded lands. The Government of India has been actively exploring its biofuel potential since 2001 (Government of India, 2005, 2006). The biofuel policy adopted in 2009, an important milestone of India's biofuels initiatives, envisages 20% blending of both biodiesel and bioethanol by 2017.

Table 1: Biofuels policies in selected Asian countries [6,7,8].

Country	Targets for 1st-generation biofuels and plans for 2nd-generation biofuels	Blending mandate	Economic measures
(the) PRC	Take non-grain path to biofuel development	Ethanol: trial period of 10% blending mandates in some regions	Ethanol: incentives, subsidies and tax exemption for production Diesel: tax exemption for biodiesel from animal fat or vegetable oil
India	No target identified Promotion of Jatropha	Ethanol: blending 5% in gasoline in designated states in 2008, to increase to 20% by 2017	Ethanol: excise duty concession Ethanol and diesel: set minimum support prices for purchase by marketing companies
Indonesia	Domestic biofuel utilization: 2% of energy mix by 2010, 3% by 2015, and 5% by 2025 Seriously considering Jatropha and cassava	Diesel: blending is not mandatory but there is a plan to increase biodiesel blend to 10% in 2010	Diesel: subsidies (at the same level as fossil fuels)
Japan	Plan to replace 500 ML/year of transportation petrol with liquid biofuels by 2010. Promotion of biomass-based transport fuels	No blending mandate upper limits for blending are 3% for ethanol and 5% for biodiesel	Ethanol: subsidies for production and tax exemptions
Malaysia	No target identified Promotion of Jatropha, nipa, etc.	Diesel: blending of 5% palm oil in diesel	Diesel: plans to subsidize prices for blended diesel
Philippines	No target identified Studies and pilot projects for Jatropha	Ethanol: 5% by 2008; 10% by 2010 Diesel: 1% coconut blend; 2% by 2009	Ethanol and diesel: tax exemptions and priority in financing
Thailand	Plan to replace 20% of vehicle fuel consumption with biofuels and natural gas by 2012 Utilization of cassava	Ethanol: 10–20% by 2008 (Gasohol 95) Diesel: 5% (B5) mix in 2007 and 10% (B10) by 2011	Ethanol: price incentives through tax exemptions

Bioethanol in India is currently produced from molasses (a byproduct of sugar manufacturing) and India is considering the possibilities of using sugarcane juice to increase bioethanol production. It also hopes to increase energy security by launching one of the world's biggest non-edible oilseed-based biodiesel industries (Government of India, 2009a; Altenburg, 2010). Jatropha and Pongamia are the two prominent oilseed plants undergoing experimentation for biodiesel production. Limitation on land availability for food and fuel production is evident from the high population density of 350 persons per sq. km. Thus, we need to access the socio-economical and environmental implications of biofuel production on GHG benefits, land available for food production, biodiversity etc. This paper is aimed at assessing the above mentioned implications of the proposed biofuel programme in India.

2. Crops and Technologies used in Biofuel production

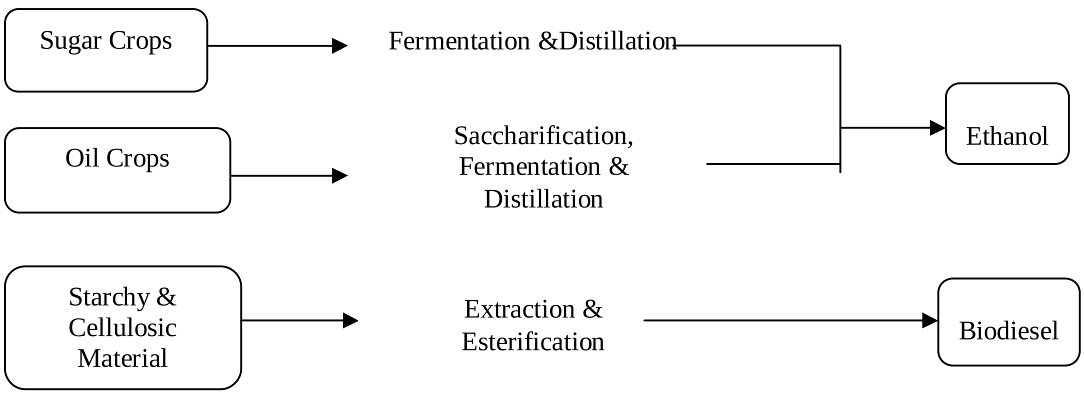
Both liquid and solid biomass fuels are used for the production of biofuels but traditionally only solid biomass (fuel wood and agro residues) was the energy source for cooking, heating and other applications like power generation. Biofuel production is the most advantageous of all its other applications.

Table 2: Biofuel:Crops used and Yield.

Technology	Biofuel	Crop/process	Global average yield
First generation[a]	Ethanol	Sugarcane	5000 l/ha/yr
		Maize	2370 l/ha/yr
		Sweet sorghum	3000 l/ha/yr
	Biodiesel	Palm oil	4590 l/ha/yr
		Jatropha	1250 l/ha/yr
		Soybean	600 l/ha/yr
Next generation[b]	Ethanol	*Biochemical*: Enzymatic hydrolysis	110–300 l/dry ton
		Thermo-chemical: Syngas to ethanol	120–160 l/dry ton
	Biodiesel	*Thermo-chemical*: Syngas-to-Fischer Tropsch diesel	75–200 l/dry ton

[a] *Source*: Sims et al. (2008), Mielke (2007), Jongschaap et al. (2007), Fresco (2006), Thow and Warhurst (2007).
[b] *Source*: Sims et al. (2008).

Table 3: Biofuel: Feedstock & corresponding fuels.



Theoretically, biofuels can be produced from any organic material, but based on the type of crops, cultivation practices and the process involved biofuel crops are classified as first and next generation crops. Examples of these crops are as follows: _

First generation crop/feedstock: Jatropha, palm oil, soybean (for biodiesel); maize, sugarcane, sweet sorghum, wheat, cassava (for ethanol), etc. Second/next generation: Woody biomass, tall grasses, agricultural and plantation residues largely for ethanol, etc. Also we divide the biofuel feed stocks into 4 broad categories based on the feedstock efficiency, namely: (1) high-efficiency feed stocks(e.g. palm oil, sugar cane); (2) moderate efficiency feedstocks (e.g. corn, soybean, rapeseed, sugar beet); (3) feedstocks under development (e.g. sweet sorghum, Jatropha); and (4) dedicated energy feedstocks (e.g. switch grass, miscanthus, short rotation crops, algae etc.) [FAO,2008].The various crops and processes used in biofuel production are given in Table2 and 3 respectively.

2.1 Land Use and Biofuels

According to the ministry of agriculture's report the major land usage is in terms of use of land for crop production followed by forests and wastelands. Irrigated land is just 40% of the total area. Land area required and the land category for growing biofuels is at the heart of the debate on the environmental and economic impacts of biofuel production. Land used for biofuel production was estimated to be around 13.8 Mha in 2004, accounting for about 1% of current cropped area (IEA, 2006). Area estimate reported in Ravindranath et al. (2009) is 26.6 Mha in 2007.Because of the increasing demand for biofuels the pressure on land and other resources is increasing. sugarcane in India is essentially a food crop (sugar production), thus, may have limited potential for meeting the biofuel demand. Currently the ethanol production in India is largely sugar molasses based. Growing sweet sorghum is a feasible option for marginal lands, though the yields are likely to be low. According to the Planning Commission (2003) Jatropha is a main biodiesel crop for India and it is proposed to use only marginal or wastelands for biodiesel plantation. Thus, the yields are likely to be on the lower end of the range and the land required could be anywhere up to 21 Mha. The planning commission has set a target of raising Jatropha plantations on an area of about 11 Mha by 2020, which can produce 7.3 Mt of biodiesel, which can meet only 21% of projected biodiesel demand of 2020-high scenario (33.5Mt) whereas it can meet about 57% of the biodiesel demand under 2020-low scenario. In the case of palm oil, the land required for meeting 2020 demand will be lower at 8.2 Mha, since the yield of palm oil is likely to be far higher than Jatropha. Palm oil production requires humid conditions with high rainfall or irrigation. Further, palm oil is edible and currently being imported from other countries. Thus, there is a limited potential for large-scale palm-oil production in India for substituting biodiesel.

2.2 Food Security and Agriculture

To assess India's policy options with respect to biofuels and food security, a global dynamic CGE model calibrated to the global trade analysis project (GTAP) database can be used [www.gtap.org]. The model is applied to assess the direct and indirect feedback effects of biofuel policies in global context such as macro economic impact of oil price increase, 20% biodiesel standard, 20%bioethanol standard, energy efficiency improvement and food productivity increase. To better understand the influence of global energy price uncertainty on the Indian economy and options available to policy makers, five basic scenarios are considered, as shown in Table4.

Table 4: Policy Scenario(Gunatilake et al, 2013)

Scenario	Description
S1	Reference case, global oil price increase by 50%, 2010–2030
S2	Scenario 1 with 20% biodiesel and standards.
S3	Scenario 2 with 20% biodiesel and ethanol standards
S4	Scenario 3 with 1% annual energy efficiency gains.
S5	Scenario 4 with 1% food productivity growth

The studies are indicative of the fact that biodiesel has a potential to offset the negative economic impacts of oil price hikes. One key assumption used in the analysis is that biodiesel crops will be grown in waste or fallow lands and there won't be any displacement of food crops. This approach has merit in a stable market environ- ment, but if the prices of food, land, or both were to escalate significantly, marginal or wastelands may be reclaimed to produce food. Incentives and a stable, conducive business environment for biodiesel may induce conversion of food lands for biodiesel crops, undermining food security .Likewise, today's food crop land could be expanded if the relative price of food is high enough to justify investments inland reclamation, forest conversion ,or other expansion of farming . Biofuel production is likely to have direct as well as indirect effects on food security with more land in developing countries being diverted to biofuel production due to lower cost of production, particularly of labor (Worldwatch Institute, 2006). According to several reviews (FAO, 2008; Bates et al., 2008; Pen˜ a, 2008) the growing demand for biofuels feedstock has already contributed to rising food prices. The increased global biofuel demand during 2000–2007 accounted for 30% of the increase in weighted average grain prices; the biggest impact was on maize prices, as the increased biofuel demand accounted for 39% of the increase in prices. In future, India too could face similar situations with respect to food prices with the growing demand for biofuels as targeted by the government of India, but if the area for biocrops is limited to wastelands we won't face any problems.

2.3 Environmental Impacts

Use of herbicides, pesticides and nitrogenous fertilizers will lead to eutrophication of water bodies and thus will affect the aquatic biodiversity. However, in India since the dominant biofuel crop Jatropha is likely to be grown with no irrigation and no or marginal fertilizer application, the pollution of water bodies is unlikely. Further, the wastelands are not suitable for irrigation. The convention on biodiversity(CBD) has all the regards for both positive as wel as the negative impact of biofuel production on biodiversity Sala et al. (2009) and FAO (2008) stated that increased biofuel production will have negative implications on biodiversity due to (i) habitat conversion and loss; (ii) agricultural intensification; (iii) invasive species; and (iv) pollution. Currently the understanding of the implications of biofuel production from first generation and next generation crops is less well understood, requiring more research.

3. Conclusion

Through this paper an attempt was made to analyze the implications of potential biofuel programs from the environmental and socio- economic perspective because of the rising interest of India in Befouls Production. The land required for meeting a 20% petroleum fuel substitution target by 2020 ranges from a low of 3.82 Mha to a high of 93.26 Mha depending on the biofuel crops selected, the potential yield and the biofuel crop scenarios chosen. Thus, the land required is feasible given the extent of available wastelands in India. One of the most important findings in our study may be the finding that the exact magnitude and source of the impact of befouls on the developing world depends on two important factors. One is the international oil price. The other is the degree of possible substitution between biofuels and gasoline. On the other hand, there are more intangible, longer-term dynamic effects that might come with biofuels. With higher prices, as in any industry, there will almost certainly be more opportunities for agricultural investment from both governments and the private sector. If increasing investments in agriculture that are induced by higher food prices end up raising agricultural productivity, this may be a source of additional output (and income) that can at least in part off-set the rise in agricultural prices from the expansion of the biofuel industry. Biofuel production in India particularly, production of Jatropha on wastelands under rain-fed conditions is unlikely to have any adverse implication for availability of water for food production. However, caution is required in interpreting the environmental and socio-economic implications of biofuel production due to limited field experience as well as absence of evidence from the field studies on the negative impacts of biofuel production. India has to develop and adapt sustainable biofuel production practices to minimize any adverse impact and to promote potential synergies with respect to reclamation of degraded lands, creation of rural livelihoods and promotion of energy security. India can go for next generation biofuels which are advantageous over the first generation crops and include the potential to use a wide variety of feed-stocks, residues and wastes and even whole plants, with potentially higher biofuel yields per hectare.

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